About an electric pulse method of grinding gold ore

Abstract. The article deals with an electric pulse method for grinding gold-containing ore based on the use of pulsed shock wave energy resulting from an underwater spark discharge. The proposed method is the most appropriate in production conditions, since it allows you to effectively crush and grind the necessary materials to the desired size and control the granulometric composition of the finished product with high selectivity. The proposed technology reduces dust pollution during working hours.

Improvement of the technology of enrichment of the raw material base of the industry makes it possible to expand and use for processing the reserves of new deposits of non-ferrous, noble and rare metals. As a rule, the content of noble components in the ores is very low, as well as in the concentrates extracted from the final tailings. In this regard, the complete extraction of valuable metals from ore is impossible without the use of modern technologies and methods of enrichment. To increase the degree of extraction of metals and ensure the integrated use of technogenic raw materials, the improvement of selective flotation is used, which is the main reserve in the production of non-ferrous metals and, to some extent, determines the success of metallurgical processing of concentrates [8-10].

The objective of this work is to develop a integrated electric pulse technology for the destruction of materials to extract valuable components from natural and technogenic materials.

The propose method of grinding ore is based on the use of the energy of a pulsed shock wave resulting from a spark discharge in a liquid. The operating medium in electric impulse crushers is technical water. The main physical processes accompanying the electric discharge in liquid dispersion media were studied and described in [11, 12]. The electrical discharge in a liquid is accompanied by fast-flowing, high-gradient processes at high pressure. A distinctive feature of this process is that the conversion of electrical energy into mechanical energy takes place without intermediate links, which increases the efficiency of the plant and ensures reliable, durable operation [13].

The electric pulse plant and grinding features

As the results of experimental work show, the crushing and grinding method used is efficient, economical, environmentally friendly, and the crushing unit is easily integrated into the production line [14].

A distinctive feature of the proposed technology is that the processing of ore and technogenic raw materials using the energy of the shock wave released by electropulse effect makes for obtaining a product of the required size that is quickly crushed and purified from impurities, which can then be used directly for subsequent enrichment.

To get the optimal characteristics of crushing and grinding of gold-bearing ore and technogenic raw materials, a three-phase electric pulse plant (TEPP) using the Yutkin effect and a working node were developed and constructed in the "Electrohydrodynamics" laboratory of the physical-technical faculty of E.A. Buketov Karaganda State University [15].

The block scheme of a three-phase electric pulse plant (TEPP) is shown in Figure 1. Structurally, the plant consists of a high-voltage power supply HPS-25-8 (A1), a pulse capacitor with built-in protection unit (C1) and an operating commutation switch (FV1).

Fig. 1. Block scheme of the electric pulse plant: A1 – a high-voltage power supply HPS-25-8, FV1 – a safety unit, C1 – a capacitor battery, FV1 – a commutation switch, R1 – a charging resistor (PEV-50-120), R2 – load or working channel, X1 – connector, a three-phase plug.

The high-voltage power supply (A1) is designed to charge a capacitive storage in various devices. In accordance with standard technical requirements, the charge-discharge circuit of a high-voltage power supply consists of a step-up power supply, a capacitor battery, a safety unit, an operational discharger, a charging resistor, and a load. The supply is a voltage regulator, made on the basis of an autonomous inverter. The constancy of the
voltage on the storage capacitor is maintained by the control circuit using a feedback system. The high voltage supply uses a control circuit that provides for regulation, stabilization, voltage measurement of the power supply and limiting the maximum load current. Feedback to the regulator is provided from the voltage sensor.

The high-voltage part of the supply is arranged in a plastic box with dimensions of 190x130x70 mm. This box contains voltage multipliers, a resistive voltage divider, a current-limiting resistor. The purpose of the current-limiting resistor is to protect the high-voltage power supply from the effects of a reverse voltage wave with an amplitude of 25 kV, formed in the cable that connects the supply to the load. On the operating desktop of the control panel of the HPS-25-8 power supply, there are switches and a screen for regulating the control, elements of protection, switching and indication. The output power of this source is 8 kW, the maximum stored energy is 40 kJ.

**Material and experimental technique**

To carry out experimental work, we used natural ore from the deposits of Kazakhstan – Akbastau mine and technogenic raw materials of Akshatau ore [16].

In the most recent studies, the initial diameter of the ore was 20 mm, and that of technogenic raw materials it was from 1 to 3 mm. The initial parameters of ore and technogenic raw materials are selected for purposes of energy saving for preliminary grinding of large pieces of material. In the course of the experiment, the preset value of the crushed ore and technogenic raw materials was chosen to be 0.2 mm.

Previously, all the experimental work on the crushing and grinding of various ores (for example, the ores of the Annensky, Nurkazgansky deposits) in the "Electrodynamics" laboratory was carried out using a three-phase electrohydraulic pulse setting (Iskra-M). Optimum regimes for the setting were obtained. However, this setting does not make for complete grinding of the ore with an initial diameter of 20 mm or more [16].

In this regard, the subsequent experiments were carried out using a three-phase electric pulse plant (TEPP) and the results obtained were compared with data obtained using Iskra-M.

To select the optimal operating parameters of TEPP electric pulse plant, crushing and grinding of materials were carried out at different parameters of capacitance (C) of capacitor batteries (0.25-1.05 μF) and interelectrode distance (lp) at the switching device (8-14 mm). The effectiveness of the crushing and grinding regime was determined by the mass content of the obtained fractions.

**Results and discussion**

The results of experimental tests carried out using the electric pulse plant with a high-voltage power supply (HPS-25-8), it was found that the grinding degree of Akbastau ore with an initial diameter of 20 mm, with a capacitor battery capacity of 0.25 μF was 2.7%, 0.4 μF – 7.1%, 0.65 μF – 12.3%, 0.8 μF – 13.2%, and 1.05 μF – 15.2%.

Further experiments were carried out at different values of the interelectrode distance at the switching device. Figure 3 shows that the smaller the initial diameter of the fraction, the higher the product yield. With an increase in the interelectrode distance at the switching device, I_p = 8 – 14 mm ground to 0.2 mm in constant values of the capacitor battery capacitance C=0.8 μF and the number of pulse discharges N=1000 increased in the following range: the Akbastau ore with an initial diameter of 15 mm – K=9 16.3% [16], 20 mm – K=7 13.7% (Iskra-M), 20 mm – K=11 16.5% (TEPP).

![Fig. 2. Dependence of the grinding degree of Akbastau ore (up to 0.2 mm) on the capacity of capacitor batteries](image)

![Fig. 3. Dependence of the grinding degree of Akbastau ore (up to 0.2 mm) on the discharge energy and on the interelectrode distance at the switching device of the TEPP](image)

<table>
<thead>
<tr>
<th>Initial diameter of fraction (d0, mm)</th>
<th>The diameter of the fraction of the obtained product by the electric pulse method (d, mm)</th>
<th>Degree of grinding of Akshatau technogenic raw materials (K, %)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.063 MM</td>
<td>0.2 MM</td>
<td>0.7 MM</td>
</tr>
<tr>
<td>1</td>
<td>35.6</td>
<td>36</td>
</tr>
<tr>
<td>3</td>
<td>28</td>
<td>33</td>
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</table>

In this case, the initial technogenic raw material was ground completely and the percentage of the ground product was 92%.

**Conclusion**

Based on the above data, we can draw the following conclusions:

- optimal energy and geometrical characteristics of the electric pulse plant for processing natural and technogenic raw materials were obtained;
- the dependences of the grinding of natural ores on the interelectrode distance at the switching device, capacitor battery capacitance and energy discharge were found.

As practice shows, at lower energy values from the established parameters, the grinding degree decreases by 20-25%, and at higher values, the energy consumption for crushing ores increases by 10-15%.
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